PCT/AU2004/000529

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Patent Specification (Australia)

THISS Pty Ltd

Radio Network Assignment and Access System

Provisional Application

Filing Date: 23rd April 2003

THISS Pty Ltd Ref: THISS-ENG-PAT-010 Issue 0.3

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Field of the Invention

The present invention relates generally to radio networks, and particularly the implementation of radio satellite network circuit assignment system and related operational procedures.

Background

This invention identifies a system for the assignment of radio network circuits between multiple users, using a novel network management access scheme. This radio network access scheme is specifically described for a satellite access scheme, but, the general principle operation could be applied to any generic radio network.

In radio networks a general system requirement is the management and allocation of "a pool" radio channels between multiple radio terminals, as users require access for a specific service. This allows the network to support a very large number of terminals, which are allocated shared radio circuits on demand for the period of time that the users requires that service. This is termed Demand Assigned Multiple Access (DAMA) communication network.

Radio networks that do not support a DAMA capability have to use permanently assigned carriers to support traffic, on a permanent leased arrangement which makes the radio channels very expensive and un-useful for those users that do not use the radio link a high percentage of the time. Other radio networks seek to introduce either manual operational procedures for requesting channel or some automatic selective procedure whereby a user takes a shared radio channel and then excludes other users selecting that channel, commonly termed "Party line". In these cases other users are excluded or "locked out" of the network for the period of time that a user is using the shared party line.

Radio networks use a combination of Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA) as generic schemes for the sharing of radio spectrum. These well known techniqu allow network operators to create channel pools that are typically allocated between terminals and a hub for the duration of a particular service requested by the user.

Communication may then typically take place between the terminal and the hub using either circuits switched network allocation where a pair of radio channels are allocated in each direction between the terminal and the hub, or using a packet switched technique whereby short packets are transmitted over the radio link using specified time reserved packet allocations.

In all cases the network provides for a combination of signaling channels for the establishment and clear down of specific radio communication channels between user and hub and communication channels over which the actual user data or service traffic is transmitted. These signaling channels are typically a combination of both dedicated out of band signaling channels using dedicated radio channels, or in-band

signaling where signaling is integrated with the actual channel that has been allocated for the transfer of the user data.

The management of these signalling channels, and the allocation of radio bearers is critical to the operation of the radio network and requires complex, dedicated equipment which performs critical network management aspects.

In satellite networks this is specifically complicated as large numbers of users will be sharing a small number of communication channels. For example, mobile satellite networks such as Inmarsat, and Domestic satellite operators typically (eg Reference 1) use complex redundant computer systems to provide centralized facilities for the allocation of channels using specific radio frequencies.

Even more complex network management faciltites are used by other mobile satellite networks such as Globalstar or Iridium which use combination of frequency and time/code division multiple access schemes to allocate channels between users.

Other satellite networks such as fixed satellite networks using Very Small Aperture Systems (VSATs) use very complex TDMA and CDMA packet based access schemes over high data rate carriers in addition to channel frequency allocations in assigning capacity between users and centralized gateway earth station facilities. These networks have centralized dedicated computer equipment for the management these radio channels between large number of remote terminals. (eg References 2, to 6).

Equatorial Communications in 1984 introduced a novel form of CDMA multiple access network (US Patent 4,455,651) which identified how a VSAT system could be simplified by providing a CDMA in-bound access scheme where each terminal was assigned a unique spreading code and a bank of channel units were implemented at the Gateway Earth station that could receive any one of the remote signals. The problem with this network design was that each remote VSAT transmitter either required a paired dedicated channel unit receiver at the Gateway, or the receivers at the Gateway had to cycle through the different potential code sequences resulting in increased data throughput times which was unacceptable for burst mode VSAT traffic. The Equatorial system therefore suffered significant operational complexity and manpower cost in managing channel units at the Gateway in providing a burst mode VSAT network, and is no longer operational (Reference 7).

More recently satellite networks have evolved to use of integrated telephony and data services and have developed integrated packet based communication services using generic network protocols such as ATM, TCP/IP and Voice Over IP (VoIP) services. The use of these protocols however has not changed or altered the requirements for the implementation of radio network access management schemes using classical radio network techniques.

This invention describes a greatly simplified system for the management of channels between large number of terminals without the requirement for a complex radio network management facility. Whilst at the same time not suffering from the channel unit receiver operational complexity issues at the Gateway Earth Station.

Summary

The precise form of the this invention is described for a satellite network using satellites operating in the geostationary arc, with terminals which operate at C Band (eg 4 to 6 GHz) frequency allocations. The satellite would typically use a Hemi or Zone regional sized high gain beam. The remote terminals which may be fixed, portable or mobile equipment depending upon the terminal antenna configuration, communicate over a two way satellite links with a Land Earth Station (LES) which acts as a Network Gateway into the terrestrial network. This terrestrial network may comprise any form, but, would typically use either Public Switched Telephone Network (PSTN), data networks, or generic public Internet or Corporate Intranet. The terminals are envisaged to operate with relatively low gain directional antennas, with gains varying between 15 and 30 dBi..

The invention is a procedural system concept whereby through the use of standard well specified data network connected access session protocols, a DAMA radio system may be implemented whereby radio resources are efficiently and effectively shared between multiple users and the central Gateway interconnection, by an inventive relationship between radio channels and the data network protocols within an innovative network architecture. The use of GPS receivers in the terminals, enables the terminals to automatically select pre-assigned channel access frequencies and codes based on the geographical location of the terminal, and at the same time provide satellite timing and path delay compensation in accessing the Gateway Earth Station so simplifying the Gateway CDMA receiver implementation. Thus enabling a complex DAMA radio network to be implemented, with no specific centralised radio channel DAMA radio network management facility, greatly simplifying the overall network design.

The system design also allows for portable and mobile terminal equipment which may not always support a connected session to the terrestrial network, by the integration of a separate packet data transmission capability at the Gateway which enables a Short Message Service (SMS) to be also implemented for contacting and communicating the terminal when a session is not active. A previous international patent application PCT/AU02/01591 describes such a packet data satellite network, and the current invention allows for the integration of this packet data network by a direct interface at the said Gateway Earth Station.

Other aspects of the invention are also disclosed.

This includes a brief description of a similar network architecture and operational procedure for an L band mobile satellite system which operates at 1.5 and 1.6 GHz.

Brief Description of the Drawings

A network architecture diagram for the overall system is provided in Figure 1.

An example protocol stack for the architecture is provided in Figure 2.

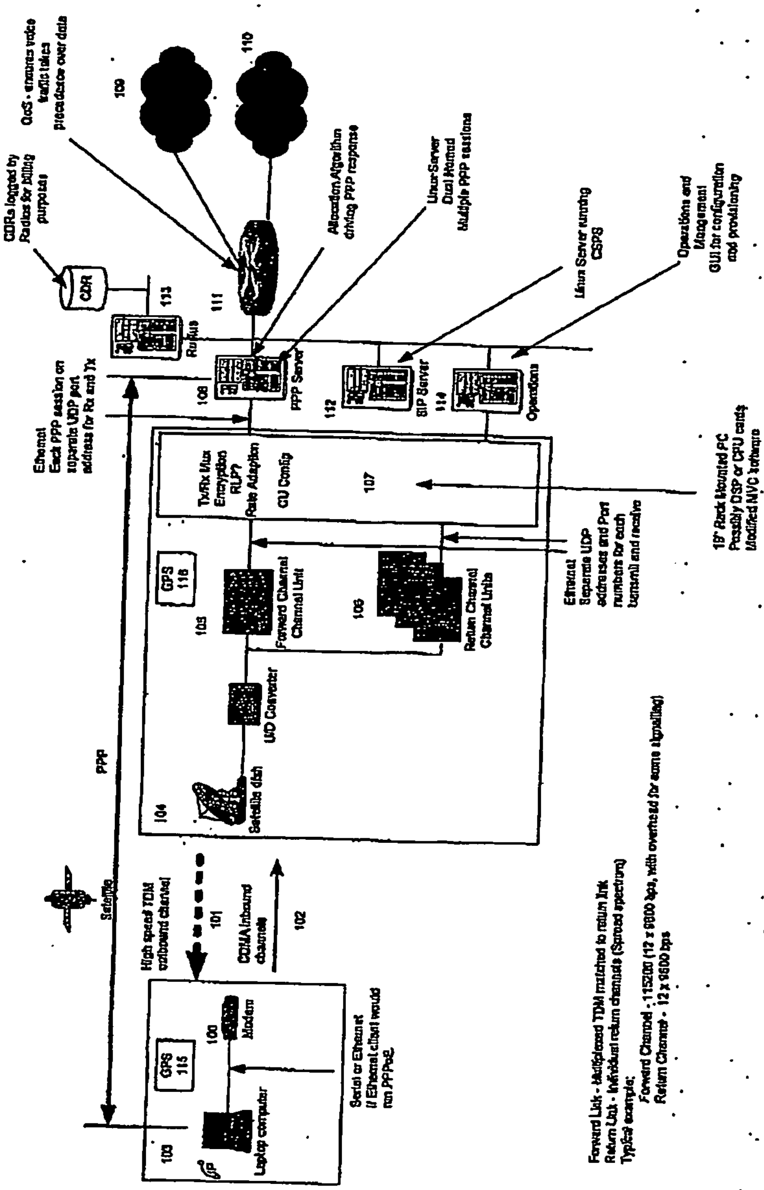

Figure 1: Network Architecture

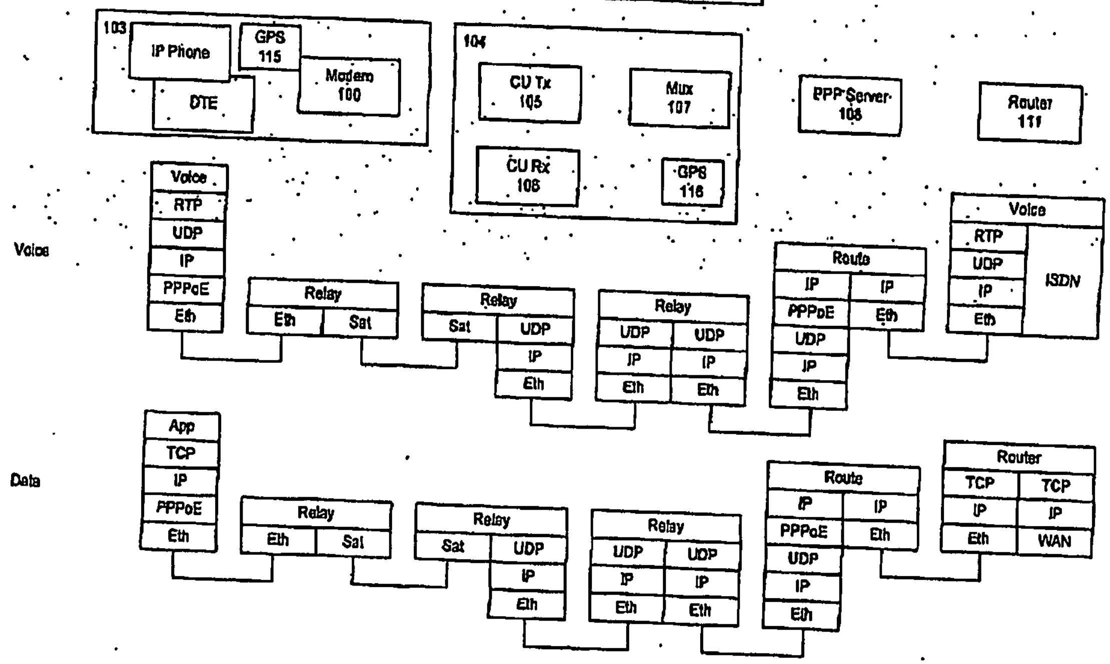

Figure 2: Example Protocol Stack

Detailed Description Including Best Mode

Where reference is made in any one or more of the accompanying drawings to steps and/or features, which have the same reference numerals, those steps and/or features have for the purpose of this description the same function(s) or operation(s), unless the contrary intention appears. The drawings describe the overall implementation of the network, and conforms to well known technical designs and features for a C band satellite system, including terminal and Gateway sub-systems including antennas, Radio Frequency (RF) components, radio modems, channel units, terrestrial network components and other related aspects for a satellite radio network.

The key network features related to the invention are as follows as per Figure 1:

1. A High Rate TDM outbound channel (101) transmitted from the Gateway (104), to the Geo-stationary at the C Band satellite band (6.0 GHz) and then retransmitted from the satellite at the paired satellite frequency band (4.0 GHz) to be shared between pre-assigned users (103) operating in the allocated outbound frequency band in that particular channel assignment. A typical channel bandwidth would be 5 MHz, with a 200 kbps shared outbound channel supporting up to 20 simultaneous active users, with typically 400 users assigned to that specific outbound radio spectrum;

2. The outbound channel may optionally use spread spectrum modulation to overcome adjacent satellite interference when operating with medium gain, broad beam-width terminal antennas. Typical code spreading ratios are between 11 and 65, using standard code sequences, with BPSK or QPSK modulation schemes, using Turbo Convolutional codes, including tiered codes to ease acquisition with significant frequency offsets wrt the channel data rate;

3. To support more users additional outbound channels are assigned in 5 MHz increments. Typical C band satellites use multiple 72 MHz transponders such that a large number of TDM outbound channels may be allocated for the overall system;

4. Each outbound channel has a pre-assigned number of inbound channels (102) which support transmissions from the terminal at C band (6 GHz) transmitted over the satellite and received at C band (4 GHz) at the Gateway Land Earth Station;

5. The terminal uses a medium gain C band antenna of between 15 and 30 dBi, whilst the Gateway Land Earth Station comprises a large antenna generally between 8 and 32m diameter providing antenna gains in excess of 50 dBi. The C band satellites use various transponders termed Global, hemi-spherical and Zone beams with different radio signal "footprints". This system is designed primarily to operate using high gain regional coverage hemi or zone beams;

6. Each inbound channel is directly related to a specific outbound channel. The bandwidth of the inbound channel does not need to match the outbound channel, and a typical channel bandwidth would be 2.5 MHz, with two lots of return channel spectrum allocated for every outbound channel allocation.

7. Thus a typical C band transponder allocation would be in 10 MHz increments, with a single transponder supporting 7 sets of channel allocations or 2,800 users. A typical single C band satellite will support up to 88 satellite transponders;

8. Each return channel bandwidth allocation has a capacity of up to 22 simultaneous users, through a predefined multiple access arrangement. A preferred multiple access arrangement is CDMA whereby a unique spread spectrum code is assigned to each of the terminals operating in that frequency band. The spreading code will use a standard Code sequence with BPSK or QPSK modulation with turbo convolutional codes, of which a preferred embodiment is a tiered code which can support significant frequency offsets wrt the overall data rate. As two return channels are allocated to each outbound channel up to 44 active users may access the radio network at any one time using the two sets inbound channels;

9. An advantage of using a spread spectrum return channel is that the network capacity has a soft limit whereby as additional users try to operate on the return channel, a gradual reduction in network throughput occurs as the self-interference increases beyond the design limit causing channel error. A further advantage is that the terminal antenna requirements, for meeting the ITU "off axis" flux density transmit EIRP requirements are simplified by signal spreading;

10. The return channel data rate does not need to match the individual per user outbound channel rate but would typically exceed or match the per user outbound rate. A typical implementation as described would use a forward channel nominal per user rate of 10 kbps and a return channel data rate of 9.6 kbps on a beam at the edge of satellite coverage, and 32 kbps at the centre of the satellite beam;

11. The return channels have a greater throughput and number of channels than the forward link, as the forward link throughput is satellite power limited.

12. The satellite network uses a circuit switched two way channel allocation between user (103) and central gateway (104), which typically uses packet data structure conforming to the internet protocol termed UDP or TCP/IP. This protocol is used to support telephony using standard Voice Over IP (VoIP) and other data services;

13. The terminal (100) comprises a radio modem, Global Positioning System (GPS) Receiver and standard data communicating equipment (DCE). To support IP telephony executing on the lap top (i.e. Soft Phone) the terminal

simply provides a path between the personal computer and PPP server. To support standalone IP phones or analogue phones requires the use of an IP router to be embedded into the terminal as shown in Figure 1.;

14. The Gateway comprises one or more Outbound radio channel modems (105) and a number of Return channel modems (106) with a multiplexing device (107) used to provide an interconnection to a PPP server (108) which interfaces with the PSTN (109) or Internet (110) via a standard router (111). Either a specific dedicated return channel modem is allocated at the Gateway for every remote terminal, or a return channel modem is configured to receive and distinguish between different user CDMA code sequences. The multiplexing device provides a connection to the PPP server using UDP port addresses which are unique for each terminal. The multiplexing device connects to the Forward Channel Unit using one UDP port address and provides the Forward Channel Unit with the TDM frame payload in a continuous mode. The multiplexing device receives frames of data from the Return Channel Units based on a unique UDP address per Return Channel Unit. If the Return Channel Unit supports multiple connections from multiple terminals, then the frame will contain the Terminal ID of each terminal so that the packet can be routed to the correct PPP connection running on the PPP server. The traffic from the PPP server to the terminal is non continuous and is based upon the users instantaneous traffic profile. This allows the forward link to be statistically multiplexed;

15. The terminal use standard protocols such as Internet PPP or similar data protocol between user and gateway for management of data sessions when the users is actively accessing the network. This protocol is used to establish a call session, including user identification and authentication;

16. A permanent or pre-assigned channel allocation is made to each terminal for each satellite in the network, such that the terminal can access a shared TDM outbound channel and two sets of return channel spectrum allocations on every satellite;

17. A terminal knowing its position accurately through use of a GPS receiver and uses a database of frequency and code allocations for that area or specific satellite select a specific satellite frequency and code pair, and seeks to identify a known Outbound TDM channel frequency. On acquiring that channel the terminal demodulates the signal and ensures that it has locked on to the appropriate Outbound TDM. The terminal may also use the received signal strength indication to ensure its antenna is optimally pointed at the desired satellite using manual or automatic procedures;

18. The terminal now monitors all Outbound TDM channel slots to determine if any packets are addressed to the terminal using standard TCP/IP packet headers or as a further option pre-assigned unique satellite network Packet Identifiers (PID's) which were pre-allocated to the terminal on terminal registration. The terminal can also monitor the received signal strength, BER

or other signal quality scheme and identify if a higher rate or a lower rate Outbound channel data rate may be available for the terminal operation. The outbound data rate selection may also be used to set the inbound channel data rate for initial access requests;

19. The terminal is now ready to initiate transmission to the Gateway, and can access the network by the transmission of standard PPP network call start-up procedures using the pre-assigned radio channels based on the geographical position of the terminal. The GPS receiver also allows the terminal to calculated the path distance to the selected satellites and with the reception of the Outbound TDM channel is able to make code timing and frequency adjustments to compensate for different path delays or frequency offsets. The session establishment uses specific PPP request packets which are received by the PPP server and are acknowledged using standard PPP formats transmitted on the forward channel. The PPP specifications allow for a specified time out interval whereby if the request packets are not received within a specified time (nominally not less than 800ms) the session time-outs. All session connections are initiated by the terminal, but, once session is connected the terminal can receive data connections and voice calls.

20. In the event that the forward channel has reached its maximum capacity limit and cannot support additional users then the PPP server will not respond to any PPP request packets from the remote terminal.

21. An implied signaling system between the remote terminal and gateway has been used whereby no response from the gateway is termed a call establishment failure and the terminal stops accessing the network until an automatic retry interval or the user manually tries again.

22. Voice calls can be initiated from the terminal or PSTN. Session Initiation Protocol (SIP) provides an end to end client server session signaling protocol. Calls to the PSTN or other network are supported using the SIP protocol and voice gateway integrated into the Internet Router (111). For terminal originated calls the user's (103) IP phone sends an Invite request to the SIP server which then initiates the SS7 IAM message via the Voice Gateway (111). The called party responds which causes and ACK message to be sent to the terminal. The call is then setup between the user (103) the Voice Gateway (111) and phone within the PSTN.

23. The bandwidth required for transmitting voice over a satellite is dependant upon the choice of voice codec, the choice of underlying transmission protocol and the assumptions of voice activation. The system relies on the use of an efficient voice codec and a protocol that does not retransmit packets if they are lost. Typical implementations of voice over IP utilise Real Time Protocol (RTP) running over UDP. Using the appropriate combination of these and the use of header compression can ensure that the link bandwidth is minimised. The system must allow for the peak bandwidth on the return link and then statistically multiplex the forward link dependant upon voice activation. A

variable bit rate CDMA transmitter from the terminal would also allow the network to take advantage of Voice Activation Dectection (VAD). Typically header compression compresses the headers from 40bytes to two or four bytes.

24. To ensure that the forward link is not congested the connection between the Internet Router (111) and the PPP Server (108) is rate limited to the outbound TDM rate (101). In addition, the Internet Router (111) provides the necessary Quality of Service functionality which ensures that the voice traffic takes precedence over any other outbound traffic.

25. The terminal (103) will support both voice and data however when voice is running there is a requirement that the data takes less precedence in both directions. This is achieved by the Internet Router giving higher precedence to the voice traffic in the forward link, however in the return link the terminal must provide this traffic shaping. For the terminal solutions which utilise a PC and softphone it would be advantageous of the operating system ensured that the voice traffic was given preference. However in practise due to limitations in common PC operating systems, the terminal will receive all traffic from the PC and then ensure that the voice traffic takes precedence over the radio channel. This requires an equivalent function which is in the Internet Router.

26. The terminal will provide different interfaces so as to support dedicated IP phones, Analogue Phone adapters as well as soft phones running on personal computers.

27. Non voice traffic such as data commonly utilises TCP which is a connection orientated service. The performance of TCP can degrade rapidly if the satellite channel is errored due to the fact that TCP assumes all packet losses are due to congestion and not radio fades. To improve the performance of TCP over the satellite link performance enhancing proxies can be used which terminate the TCP streams at both ends of the link and then run an unacknowledged protocol such as UDP between the two proxies. This technique allows the proxies to control repeat requests and can make decisions based on the knowledge that the radio link is either congested or more likely errored due to propagation impairments.

28. The standard Radius server is used to generate Call Data Records (CDR's) for all data sessions such that the end terminal user will be charged on the basis of terminal useage which may be time or data packet billing arrangements.

29. The network operation may be further improved by the introduction of channel frequency and code reassignment commands to move users between frequency channels to balance the load on the network. This includes the capability of the terminal channel frequency and code pair assignments in the data base being updated over the Outbound channel satellite link using a defined protocol to ensure no erroneous data is stored in the terminal;

30. The network operation may be further improved by a congestion control flag on the Outbound channel which is used to notify when the network capacity is being exceeded and will include the capability for different priority of users to be stopped accessing the network;

31. The network operation may be further improved by the use of ALOHA burst packet mode signalling channel using dedicated channel CDMA code sequences, on both the Outbound and the Inbound link for terminals based on conventional burst mode signalling channel operations eg channel access request, channel access grant etc. The major advantage of this network operation is that an "always on" active session could be maintained

32. As described previously, the use of addition of the packet data interface for the low bit rate data services for tracking and voice codec operation.

Other Satellite frequency bands:

In a similar manner to the C band satellite system description other satellite networks operating in other frequency bands will operate in a similar manners. One such system is an L band mobile satellite system which operates at 1.5 to 1.6 GHz frequency band.

In such a network the detailed design of the air interface would be adapted to conform to the satellite operational requirements that would result in an equivalent service with an Outbound TDM narrowband (non spread spectrum) channel data rate at 640 kbps in 1.25 MHz bandwidth, and 1.25 MHz inbound channel spread spectrum system using nominal data rate 9.6 kbps.

Similar modulation and coding schemes would be used to the C band system except for the precise Turbo convolutional codes and modulation types which would could use different narrowband schemes including BPSK, QPSK, 16 QAM or even 64 QAM.

Industrial Applicability

It is apparent from the above that the arrangements described are applicable to the satellite field and more generally the radio industry.

The foregoing describes only some embodiments of the present invention, and modifications and/or changes can be made thereto without departing from the scope and spirit of the invention, the embodiments being illustrative and not restrictive.

1 References

1. AUSSAT

"Network Management Stations for Australia's MobileSat System", S. Harrison, N. Hart, A. Fuji, 14th AIAA International Communication conference, March 22-26 1992, Washington DC;

2. Viasat

United States Patent 6,539,003
Agarwal, et al. March 25, 2003
Method for acquisition and synchronization of terminals in a satellite/wireless TDMA system

3. Hughes

United States Patent 6,449,267
Connors September 10, 2002
Method and apparatus for medium access control from integrated services packet-switched satellite networks

4. Gilat

United States Patent 6,233,429
Soffer, et al. May 15, 2001
VSAT satellite telecommunications system

United States Patent 5,053,782
Levinberg, et al. October 1, 1991
Commercial satellite communications system

United States Patent 6,097,706
Fielding, et al. August 1, 2000
Demand-based connection management integrated services access terminal (ISAT) for satellite communication system

5. Equatorial

United States Patent 4,455,651
Baran June 19, 1984
Satellite communications system and apparatus

United States Patent RE32,905
Baran April 11, 1989

	Patent Specification (Australia)	

Satellite communications system and apparatus

7. IEEE Communications Magazine
Internet Access Using VSATs, Norman Abramson, July 2000 issue of IEEE *Communications Magazine*.

8. Understanding SIP
Understanding SIP **http://www.fokus.gmd.de/mobis/siptutorial/**